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Pre-COSEWIC Assessment for Lake Utopia Rainbow Smelt (*Osmerus mordax*) Small-bodied and Large-bodied Populations

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Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

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ABSTRACT

The Rainbow Smelt (*Osmerus mordax*) populations (Lake Utopia Large-bodied Population and Lake Utopia Small-bodied Population) have been scheduled for reassessment in November 2018 by the Committee on the Status of Endangered Wildlife in Canada under the federal *Species at Risk Act*. The purpose of this paper is to present current Fisheries and Oceans Canada information related to the status and trends of, and threats to, this species inside and outside of Canadian waters, and the strengths and limitations of the information. Surveys of Lake Utopia tributaries used by spawning Large-bodied and Small-bodied populations were conducted from 2012-2017 under various protocols. Observations from these surveys provide information on the timing of spawning and which streams were occupied, length frequencies and abundance of the large-bodied population in some years, and some genotyping of animals captured in streams in 2014 and 2015. Data from these surveys provide information on timing of the spawning run. Available information on threats and limiting factors that may impact this species are also presented.

INTRODUCTION

The Lake Utopia Rainbow Smelt (LURS) is a complex of two morphologically, ecologically and genetically distinct populations of Rainbow Smelt (*Osmerus mordax*) co-existing in Lake Utopia, in southwestern New Brunswick: the Small-bodied Population and the Large-bodied Population. Morphological characteristics for distinguishing the two populations include maximum length, relative eye and jaw length to body size, and number of gill rakers. The two populations were assessed in 2008 by the Committee on the Status of Endangered Wildlife (COSEWIC) as meeting criteria for separate designatable units. Both were assigned a status of Threatened due to their significance as members of a genetically divergent sympatric species pair endemic to a single Canadian lake with an extremely small area of occupancy (6 sq. km), limited spawning habitat and vulnerability to habitat degradation, fishing and the introduction of exotic species (COSEWIC 2008). The Small-bodied Population (formerly known as 'dwarf smelt') was previously designated as Threatened by COSEWIC in 2000 (COSEWIC 2000) and has been protected under the Species at Risk Act (SARA) as Threatened since 2003. A decision of whether or not to list the Large-bodied Population under SARA had not yet been made as of the writing of this document.

The Large-bodied and Small-bodied populations have been scheduled for reassessment in November 2018 by COSEWIC. As a generator and archivist of information on marine and some freshwater species, Fisheries and Oceans Canada (DFO) endeavours to provide COSEWIC with the best information available to ensure that an accurate assessment of the status of a population can be undertaken. Existing DFO information is reviewed and made available to COSEWIC and the status report authors and published on the Canadian Science Advisory Secretariat (CSAS) website.

A Recovery Potential Assessment (RPA) conducted by DFO in 2010 summarized information from scientific literature and unpublished field studies up to 2010 (DFO 2011). Advice was provided on current population status and trends, habitat requirements and potential threats to recovery (DFO 2011; Bradford et al. 2013). Abundance and distribution targets requiring annual monitoring were recommended and incorporated into the Recovery Strategy for the Lake Utopia Rainbow Smelt, Small-bodied Population,(sympatric with the Large-bodied Population) (DFO 2016a). The Recovery Strategy emphasizes the survival of the two populations together as a species pair as a broad recovery goal with the conservation of one population inherent to the survival of the other. The 2016 Recovery Strategy also includes an up-to-date description and assessment of threats to the species and its habitat, as well as a description of the species needs and critical habitat (DFO 2016a).

Other information generated by DFO since the RPA that are specific to Lake Utopia Rainbow Smelt include: estimates of the Large-bodied Population spawner abundance in Mill Lake Stream in 2014 (DFO 2016b) and 2017 (DFO 2018), a comparison of habitat attributes among Lake Utopia spawning streams (MacDonald 2017), a guide for best monitoring practices during the respective spawning runs of the two populations (MacDonald and Burbidge 2017), and environmental conditions (water and air temperatures, water levels and discharge rates) in Mill Lake Stream during the summer 2016 (Caissie and Savoie 2017).

This update on the status of the two LURS populations summarizes information collected by DFO Maritimes Region from 2012 to 2017 concerning:

1. Life History Characteristics.
2. Review of Designatable Units.
3. Review of COSEWIC Criteria.

4. A description of the characteristics or elements of LURS Large-bodied Population and Small-bodied Population habitat to the extent possible and threats to that habitat.
5. Describe to the extent possible whether the LURS Large-bodied Population and Small-bodied Population have a residence as defined by SARA.
6. Threats.

METHODS

Since the RPA, surveys of Lake Utopia tributaries used by spawning Large-bodied and Small-bodied populations were conducted from 2012-2017 under various protocols (Appendix 1). No monitoring occurred in 2011. In 2012, surveys looking for the presence or absence of smelt and eggs were conducted in Mill Lake Stream, Trout Stream, Unnamed Brook, Second (Scout) Brook and Smelt Brook. Observations occurred during daylight hours at weekly intervals as part of a project monitoring water quality and potential barriers in the spawning streams. The one exception was a visit to Mill Lake Stream at 11 pm on April 6, 2012. More frequent surveys of Mill Lake Stream, Unnamed Brook and Smelt Brook were undertaken by the Maritimes Aboriginal Peoples Council (MAPC) in 2013 with nightly checks occurring after April 4 (MAPC 2014a). Sixteen other Lake Utopia tributaries were visited by DFO from April 30 to May 1, 2013, to assess suitability for smelt passage and availability of suitable spawning habitat.

Field activities in 2014 consisted of nightly checks for smelt in Mill Lake Stream prior to and following a mark-recapture study undertaken April 3rd to April 10th (DFO 2016a) and weekly daytime visual checks for smelt and eggs in Unnamed, Second and Smelt brooks until the end of May (MAPC 2014b). Harsh weather conditions and high, turbid water flow prevented checks of the brooks from mid-April 14th to early May. Similar protocols were used during daylight in 2015 and 2016 to survey Mill Lake Stream, the mouth of Trout Stream and Second Brook weekly for the presence of smelt and eggs. Smelt and Unnamed brooks were checked once in each year. Spears Brook was checked once in 2015. Results from the daily collection of water temperatures in the spawning streams, mapping of the habitat characteristics in Mill Lake Stream and discussion of differences among spawning streams are available in MacDonald (2017).

In 2016, the Marine Gene Probe Laboratory at Dalhousie University, Halifax, Nova Scotia, was contracted to compare genotypic data from the tissue samples of 40 Rainbow Smelt collected from Mill Lake Stream in 2014 and 86 smelt from Unnamed, Smelt and Second brooks in 2015 to 603 smelt sampled from Lake Utopia in 1990, 2002 and 2003 (sampling locations and protocols as described in Bradbury et al. 2011).

In 2017, Mill Lake Stream was monitored after 11:00 pm every second or third day from March 16th to March 30th and then daily from April 4th to April 14th. Mark and recapture events were conducted by DFO on the nights of April 3rd and 14th. Visual spot checks of Trout Lake Stream (presence of smelt or eggs) were conducted while travelling to Mill Lake Stream.

Four spawning streams were checked for the presence of smelt and eggs from April 24 to May 30, 2017: twice weekly in Mill Lake Stream and Second Brook and once weekly in Unnamed and Smelt brooks, using the protocols developed by MacDonald and Burbidge (2017).

DISTINGUISHING CHARACTERISTICS OF SMALL- AND LARGE-BODIED SMELT

Phylogenetic and phenotypic analyses of Lake Utopia Rainbow Smelt indicate two genetically discrete forms: a small-bodied form and a large-bodied form (Bradbury et al. 2011). Adult body size was recommended by DFO (2011) as the most useful and practical criteria for

distinguishing the two forms: a maximum fork length <170 mm (187 mm total length) for the small-bodied form and a minimum fork length ≥170 mm for the large-bodied form. The small-bodied form also exhibits within population bi-modality in body length within the same age classes (Curry et al. 2004, Shaw and Curry 2011, Bradford et al. 2013).

The 170 mm fork length (FL) criterion is larger than the 132 mm FL (150 mm total length) used by COSEWIC (2008) to distinguish the two forms, based on earlier morphometric and genetic analyses (Lanteigne and McAllister 1983; Taylor and Bentzen 1993; Curry et al. 2004). Other criteria for distinguishing the two populations are relatively larger eyes in the small-bodied form as well as a shorter upper jaw and a higher gill raker count (33-37 vs. 31-33 in the large-bodied form) (COSEWIC 2008).

Genetic assignment of multiple small-bodied individuals to the large-bodied form suggested that an absolute phenotypic criterion for separation of the two forms is not possible (Bradbury et al. 2011; Bradford et al. 2013). These forms may hybridize and the hybrids are not strictly associated with either stream or brook habitats (Bradford et al. 2013).

LIFE HISTORY CHARACTERISTICS

SPAWNING AND RUN CHARACTERISTICS

Lake Utopia Rainbow Smelt (LURS) spawn in spring in tributary streams located within the northern basin of Lake Utopia (Figure 1). The Large-bodied Population spawn first in late March to mid-April when water temperatures in Mill Lake Stream are about 6°C or less (Curry et al. 2004; MacDonald 2017), followed by the Small-bodied Population in mid-April through May at water temperatures of 4-9 °C (Shaw 2006, MacDonald 2017). Spawning has only been documented in six small tributary streams at the northern end of the lake: Mill (Mill Lake) Stream, Trout Lake Stream, Scout (Second) Brook, Unnamed Brook, Spear Brook and Mill (Smelt) Brook (COSEWIC 2008; names in brackets are those used throughout this document). Large-bodied Population spawn in the largest tributaries on the northeast side of Lake Utopia, Mill Lake Stream and Trout Lake Stream, both of which are outlet streams for smaller lakes flowing into Lake Utopia (Curry et al. 2004). They have also been observed spawning in Spear Brook, a tributary of Trout Lake (Curry et al. 2004). Small-bodied Population spawn in smaller, slower flowing streams that are not fed by lakes located at the northern end of Lake Utopia: Smelt Brook, Unnamed Brook and Second Brook (Bradford et al. 2013). No evidence of shore spawning was observed in 2010 and 2012 surveys of lakeshore areas adjacent to known spawning tributaries (Bradford et al. 2013).

Spawning occurs at night between 21:30 and 04:30 hours with peak activity occurring from 00:00 to 01:30 (Curry et al. 2004). Some smelt (mainly male) may remain in the streams during the day. Males also appear in the streams before the females and comprise a larger proportion of the run (Bradford et al. 2013).

Large-bodied Population

The Large-bodied Population were first seen in Mill Lake Stream in early to mid-April, but not consistently in all years (Appendix 2). In 2012, smelt were only observed on April 6th, which was also the only date that year when the stream was visited during night time hours. In both 2013 and 2014, smelt were observed within Mill Lake Stream in early April but, based on anecodotal reports from residents on the lake, are believed to have started spawning earlier, by March 31st in 2013 (MAPC 2014a) and April 1st in 2014 (MAPC 2014b).

Sampling in 2015 and 2016 occurred during daylight except for a single nighttime observation on April 30, 2015 (Appendix 2). No smelt were seen in 2015 and eggs were not observed until April 29th, near the secondary culvert and near the base of the waterfall. In 2016, only a single, dead individual was observed (April 13th) in addition to eggs below the culvert. In both years, eggs were similar in size to smelt eggs but their origin as Large-bodied or Small-bodied populations could not be confirmed.

In 2017, smelt first appeared on April 4th, but nightly estimates did not exceed 200 until April 10th (Table 1). The highest numbers were observed on April 13th and April 14th with spent females appearing during the mark recapture event on the night of April 14th.

The run duration was 7-8 days in 2013 and 2014 (the 7,000 smelt reported on April 13, 2014, were smaller than those observed earlier in April 2014) and 10+ days in 2017. The run was dominated by males, with females comprising 0-40% of the smelt sampled for sex characteristics (Table 2).

Length frequencies of the early April runs show that 89% of the fish sampled in 2014 and 45% of fish sampled in 2017 were less than 170 mm (Figure 2). The apparent narrower length range in 2014 than 2017 is an artifact of sampling, as animals as large as 300 mm were observed during the 2014 mark-recapture but not recorded (DFO 2016b).

Counts of fish at 30 minute intervals in 2014 showed that the highest numbers were present between 11:30 pm and 2:00 am, with most fish leaving the stream before 5:00 am (MAPC 2014b).

There are challenges in verifying the presence of smelt and eggs in the larger Trout Lake Stream-Spear Brook system because Trout Lake Stream is wider and deeper than Mill Lake Stream, making visual detection of eggs and smelt difficult (Jennifer Shaw, DFO, pers. comm.; MacDonald 2017). Several attempts were made over the 2012-2017 time period. The culvert at the mouth of Trout Lake Stream was checked every year for indications of spawning smelt, but a few smelt were observed only in 2012 (April 13th) and eggs were observed in 2013 (April 17th) (Appendix 2). Spear Brook was checked in 2013 (May 1st) but no smelt or eggs were observed and beaver dams at the mouth appeared to prevent any migration (DFO, unpubl. data). An attempt was made to check Spear Brook in 2015 (May 6th) but water levels were too high and fast for observations.

Small-bodied Population

Small-bodied population spawning streams (Smelt, Unnamed, and Second) were checked at low frequencies over the last decade compared to streams used by the Large-bodied population, with as few as two visits to some streams in some years (Appendix 3), during daytime when much of the spawning run would be expected to have migrated back into Lake Utopia. Nonetheless, smelt or eggs were observed in Unnamed Brook, in Second Brook every year except 2014 and in Smelt Brook every year except 2016 (Appendix 3).

Ninety smelt were sampled in Second, Smelt and Unnamed brooks on May 15, 2015. These ranged from 97-140 mm (average = 120 mm, Figure 3). All but four of the 86 fish genotyped had a genotype typical of the Small-bodied Population (q (small morph>0.8) (Table 3).

In 2013 and 2014, a run of smaller sized spawning smelt was observed entering Mill Lake Stream several days after the end of the first smelt run (Table 1, MAPC 2014a; DFO 2016a). These also spawned as indicated by the presence of eggs in the stream near the end of April. The predominant size of the smelt observed on April 13, 2014, was less than those observed from April 1st to April 8th but no fish were measured (MAPC 2014b). The median length of a sample of fish taken on April 22, 2014, was 125 mm FL (range 96-173 mm, n = 20). Genetic

analyses of 15 individuals collected on this date indicated twelve were very similar to the Small-bodied Population (q (small morph genotype>0.8) and the other three with some degree of Large-bodied Population ancestry (143-173 mm FL; q (large morph = 0.25-0.66) (P. Bentzen and I. Patterson, Dalhousie University, pers comm.; Figure 3, Table 3) indicating that there is some co-mingling of the two smelt populations during spawning in Mill Lake Stream.

ABUNDANCE AND TRENDS

Large-bodied Population

Within the present decade annual estimates of smelt abundance in Mill Lake Stream have been highly variable. Daily estimates over the spawning run duration peaked at 5,000 in 2009, >5,000 in 2013, >23,000 in 2014 and >12,000 in 2017 (Table 1, DFO 2011; 2016b; 2018). No smelt were observed above or below the culvert in Mill Lake Stream in 2015 and 2016 (with the exception of a single, dead individual above the culvert on April 13, 2016) (Appendix 2), but stream checks occurred during the day only.

Visual spot checks of Trout Lake Stream reported smelt in 2012 only and eggs in 2013 only (Appendix 2). No smelt or eggs were observed in Spear Brook.

Small-bodied Population

All estimates for Small-bodied population abundance within the present decade are based on numbers reported by observers conducting visual stream checks during the day (Appendix 3). In 2013, daily observations of a Small-bodied Population spawning run were only conducted in Unnamed Stream; the run was already occurring on the first day of observation and peaked two days later at an estimated 12,000 animals (Table 4). In 2014 when brooks were checked in May, late in the usual spawning season for Small-bodied Population, a few hundred smelt were observed in Smelt and Unnamed brooks. In 2015, spawning smelt in the order of thousands were observed on May 4th in Second Brook and May 5 in Smelt Brook (DFO, unpubl. data). Thousands of spawning smelt were observed in Second Brook on May 4th in 2016, and on April 28th in 2017 (DFO unpubl. data).

REVIEW OF DESIGNATABLE UNITS

GENETIC VARIATION

Lake Utopia Rainbow Smelt (LURS) Small-bodied and Large-bodied populations meet the criteria for separate designatable units by being morphologically, ecologically and genetically distinguishable from each other. Co-occurrence of sympatric smelt populations in Lake Utopia is one of a few examples of genetic divergence occurring in the absence of geographic separation. Lake Utopia Rainbow Smelt (LURS) Small-bodied and Large-bodied populations have a common ancestor, but they have reproductively isolated themselves through different spawning times and streams and are behaving as separate species (Taylor and Bentzen 1993). Since their genetic divergence is very recent, occurring since the last glacial period 15,000 years ago, LURS provide an example of how rapidly northern temperate fishes can speciate (Taylor and Bentzen 1993).

An evaluation by Bradbury et al. (2011) of LURS phenotypic and genotypic divergence based on spawning individuals collected from 1980-2010 indicated two distinct populations as well as evidence of hybridization between the two forms. Bradbury et al. (2011) concluded that hybrids were effectively selected against, as genetic differentiation and body structure of the pair appeared stable over the two decades evaluated. Changes in local environmental conditions or

in the relative fitness of the hybrids could lead to collapse of the sympatric pair. For example, a sympatric pair of sticklebacks occurring in six small lakes in British Columbia appears to be collapsing into a hybrid swarm following the introduction of an exotic crayfish (Taylor et al. 2006).

Genotyping of the 2014 and 2015 Lake Utopia Rainbow Smelt samples classified individuals as belonging to the Large-bodied Population (large morph), Small-bodied Population (small morph) and an admixed/uncertain group based on q-values expressed as a fraction of an individual's genome derived from either a pure large-bodied or small bodied genotype. A high proportion (95%) of the 2015 sample collected from Small-bodied Population spawning streams was comprised of Small-bodied Population genotype (Table 3). The size of the sample was small from the two spawning runs in Mill Lake Stream in 2014 (Table 3), but 25% of animals from early April could be classified as Small-bodied Population or admix genotype, while 80% of the fish collected on April 22nd could be classified as Small-bodied Population. A more relaxed threshold was required to classify individuals as Large bodied Population (q(large morph>0.65)) than Small-bodied Population (q(small morph >0.8)), suggesting a low level of gene flow from the Large-bodied Population into the Small-bodied Population, and higher levels of gene flow from the Small-bodied Population into the Large-bodied Population (P. Bentzen, Dalhousie University, pers. comm).

Overall, results from the comparison of the 2014 and 2015 samples to historic samples suggest the occurrence of increased hybridization in the recent smelt samples, especially in smelt sampled in Mill Lake Stream in 2014. However, the Small-bodied and Large-bodied populations remain distinguishable (Paul Bentzen, Dalhousie University, pers. comm).

MORPHOLOGICAL VARIATION

Comparing length frequencies and gill raker counts from samples of smelt collected in 2014, 2015 and 2017 (Figures 4-6) with LURS collected between1980 and 2010 (Bradbury et al. 2011) require several caveats. First, none of the recent samples are representative of the ratio of the two LURS populations in the spawning runs. In 2014, only 40 fish were sampled in Mill Lake Stream. None were genotyped but 20 were sampled in the early April run (predominately Large-bodied) and 20 on April 22nd (80% Small-bodied Population) (Figure 4). In 2015, only brooks used by Small-bodied Population were sampled. In 2017, sampling in Mill Lake Stream was length stratified to collect information on gill raker counts and age structure of the run while minimizing mortalities of the Large-bodied Population (Figure 4). Also, gill rakers from 2014 and 2015 smelt were counted by two samplers with good agreement, but gill rakers of smelt sampled in 2017 were based on counts by one sampler, with poor agreement with a small proportion (14 fish) counted by a second sampler.

In the 2014 Mill Lake Stream samples, fish sampled during the early run were larger (median FL=166 mm) than fish from the later run (median FL= 125 mm, Figure 4). The median gill raker count of the early run was 33 gill rakers compared to a median count of 35 gill rakers for the later run (Figure 5). Two length modes are apparent in the 2015 sample length frequency (Figure 4); a median of 110 mm FL for the lower mode and a median of 126 mm for the upper mode. Figure 5 shows that the gill raker counts of smelt sampled in 2015 form a single mode (median = 36 gill rakers). The length stratified sampling conducted in 2017 prevents any comparison of length frequency distribution with 2014 and 2015 samples. Gill raker counts of the 2017 run show two modes (Figure 5), the lower with a median of 32 gill rakers, and the upper with a median of 35 gill rakers. There is a weak relationship between gill rakers and fish length in which larger fish tend to have fewer gill rakers (Figure 6).

REVIEW OF COSEWIC CRITERIA

DECLINING TOTAL POPULATION

There are insufficient data to determine the significance of annual differences in the abundance of the two LURS populations. Recent monitoring objectives for both populations have focused on confirming the presence of the two populations in the streams, mainly through qualitative observations of fish or eggs during the day.

Numbers of LURS observed in Mill Lake Stream in April peaked at approximately 5,500 in 2013, 23,500 in 2014 and 12,500 in 2017 (Table 1). The 2010 RPA reported that daily within-stream estimates of Small-bodied Population varied from 3,000 to 150,000 spawners (Bradford et al. 2013). No abundance estimates of the Small-bodied Population have been undertaken since 2010. However, large schools of smelt were observed in one or more of the three known spawning streams in 2013, 2015, 2016 and 2017 (Appendix 3).

SMALL DISTRIBUTION

The area of occurrence for the Large-bodied Population is Lake Utopia and its spawning tributaries. This population has been known to spawn in three streams: Mill Lake Stream, Trout Lake Stream and Spears Brook (Curry et al. 2004; COSEWIC 2008).

Some observations of the smelt runs from 2014 to 2017 suggest that the Large-bodied Population spawns in locations other than its known spawning streams, such as along the shorelines of Lake Utopia. The smelt run in early April 2014 aggregated and spawned in the outflow of Mill Lake Stream. In 2015 and 2016, only small egg mats and one smelt were observed in Mill Lake Stream, raising concerns about spawning failure. However, the 2017 spawning run had daily estimates as high as those of the 2014 run, and a broad length frequency and age structure 2-6 years (DFO 2018), indicating recruitment from the 2011 through 2015 year classes.

Smelt and eggs were seldom observed during spot checks of the culvert at the mouth of Trout Lake Stream (Appendix 2); however, water depths at this location are deep, making it difficult to observe indicators of smelt spawning. Since there is recent evidence of little egg deposition in Mill Lake Stream, a more comprehensive study in Trout Lake Stream is warranted to determine its current status. Spear Brook is also difficult to sample, and it also may be inaccessible to smelt in some years due to beaver dams.

The area of occurrence for the Small-bodied Population is Lake Utopia and its spawning tributaries. Since 2012, this population has annually occupied two to three of the spawning streams identified by COSEWIC (2008). Genotyping of smelt from the two spawning runs observed in Mill Lake Stream in April 2014 indicates that some Small-bodied Population are present in Mill Lake Stream at the time of the Large-bodied Population spawning run (DFO 2018). Most smelt in the second run observed on April 22, 2014, were Small-bodied Population, indicating that this population spawns in Mill Lake Stream. There was a temporal separation in spawning run timing between the two smelt populations, with the majority of Small-bodied Population aggregating and spawning later than the Large-bodied Population.

SMALL TOTAL POPULATION SIZE

The maximum daily abundance estimates of the Large-Bodied Population in Mill Lake Stream in those years in which mark-recapture experiments were conducted are 5,000 (2010), 19,636 (2014) and 10,659 (2017) (DFO 2018). The absence or low numbers of smelt in Mill Lake Stream in 2015 and 2016 (Appendix 2) suggests that the size of the spawning run in that location may not be a good indicator of population status. Alternative indicators of population

health are a spawning run composed of animals spanning an age range of two or more years and an abundance of 5,000 spawners, based on effective population size information (DFO 2018) occupying Mill Lake Stream at least once in every 3 years.

Among-stream daily estimates of Small-bodied Population in excess of 100,000 spawning smelt were reported in the 2011 RPA. No estimates have been conducted since 2010 but large schools have been observed in at least one of the three streams in each year in which Small-bodied spawning streams have been checked for the presence of smelt or eggs around the time during which spawning occurs (Appendix 3).

HABITAT REQUIREMENTS

CHARACTERISTICS OF SPAWNING HABITAT

Information on the type of substrate, water temperature and stream conditions associated with the spawning streams of the two LURS populations are described in the LURS Small-bodied Population Recovery Strategy (DFO 2016a), Recovery Potential Assessment (DFO 2011, Bradford et al. 2013) and MacDonald (2017).

In addition to the six spawning tributaries identified by COSEWIC (2008), a small brook, located between Unnamed and Second brooks (45.209N 66.798W), was observed to contain eggs in the first five metres of the stream and a few dozen smelt in 2013 (DFO, unpubl. data). This brook appears to only be accessible at high water events. Smelt eggs were also observed at this location in 2010 (Bradford et al. 2013).

Sampling of Lake Utopia tributaries where smelt spawning has not been observed indicates some habitat characteristics that make these areas unsuitable. Most of the unused streams were inaccessible to smelt as a result of barriers caused by beavers, debris or steep gradient. These streams also had higher proportions of substrate (>1.6 cm) or a lot of fine sediment and siltation (MacDonald 2017). Stream temperature profiles showed more variation throughout the spawning period and were often warmer than streams used by spawning smelt. Only Big Hike Brook (Figure 1) had many habitat features and attributes similar to Small-bodied Population spawning streams. Low discharge rates likely make this stream unsuitable for smelt spawning; while upstream portions were similar to Small-bodied spawning streams, there was little stream flow and the mouth of the stream passes through wetland rather than a beach delta (MacDonald 2017).

Characteristics of Large-bodied Population Spawning Tributaries

Two of the spawning tributaries used by Large-bodied Population, Mill Lake Stream and Trout Lake Stream, have been defined as lake-headed (COSEWIC 2008) because they are outlet streams from Mill Lake and Trout Lake that drain into Lake Utopia (Figure 1). However, spawning has also been observed in Spears Brook (Curry et al. 2004; Bradford et al. 2013), which is not lake-headed and drains into Trout Lake. MacDonald (2017) reported these three streams were significantly warmer than the Small-bodied Population spawning streams and non-spawning streams during the Large-bodied Population spawning and incubation periods (late March through April) and continued to be warmer throughout the Small-bodied Population spawning and incubation periods (late April through May).

Mill Lake Stream averages 4 m wide and less than 1 m deep (Curry et al. 2004). Spawning habitat extends from the mouth of the stream to a small 0.5 m waterfall less than 50 m upstream (Bradford et al. 2013, MacDonald 2017). The amount of area occupied during spawning varies between years. Lake Utopia Rainbow Smelt may spawn in shoal waters or on the shoreline in

some years, as has been observed in other Rainbow Smelt populations (Scott and Crossman 1973). The Large-bodied Population was observed spawning in the outflow of Mill Lake Stream in 2014.

Water flow during spawning in Mill Lake Stream is high to moderate, reaching speeds in excess of 1 m/s (COSEWIC 2008; Caissie and Savoie 2017). Water flow through the culvert may have been too strong for smelt (body speed 0.4 m/s) to swim up into Mill Lake Stream in 2014 and 2015 (MacDonald 2017).

Trout Lake Stream averages 10 m wide with slow moving water and deeper pools (Curry et al. 2004). It is mainly composed of run type habitat that passes through marsh and meadow areas before draining through a large culvert into Lake Utopia. This culvert is not considered a barrier to smelt passage although water flows at peak flow have not been measured to confirm their suitability for smelt (MacDonald 2017).

Spears Brook is much wider and deeper than Mill Lake Stream. The upstream portion meanders through forested areas but much of the lower portion drains through marsh and meadows. Beaver activity at the mouth of Spears Brook (Trout Lake end) has divided the main channel of the stream into several smaller channels. Many of the channels appear to end blindly and create a maze of channels through the marsh (MacDonald 2017).

Characteristics of Small-bodied Population Spawning Tributaries

The streams used by Small-bodied Population are not lake-headed, small (1-2 m width) and slow-flowing (<10 cm/s) (Bradford et al. 2013). Temperatures are lower relative to Mill Lake Stream and Trout Stream in the spring months (Bradford et al. 2013; MacDonald 2017). Other habitat attributes specific to Small-bodied Population spawning streams include gravel-sized substrate (<1.6 cm), a lot of forested riparian zone, shallow depth, narrow wetted-width, drainage through a sand delta directly into the lake, and low gradients (MacDonald 2017).

Habitat mapping and visual inspection of streams following Small-bodied Population spawning in 2015 indicated that organic debris created full and partial barriers to upstream fish passage in all streams (MacDonald 2017). Most egg mats were often found in areas just above a partial downstream barrier, just below a partial upstream barrier or between both types of barriers. Smelt showed a preference for smaller substrate sizes with selected sites primarily composed of coarse sands, fine sands, organic matter and some gravel.

RESIDENCE OF LAKE UTOPIA RAINBOW SMELT

No information was evaluated on the residence of the two LURS populations. The 2011 RPA suggested that egg masses resulting from spawning activity might be considered as a kind of residence because they fulfil the function of breeding and are geographically predictable in their distribution.

THREATS

Four major categories of threats with the potential to negatively impact Lake Utopia Rainbow Smelt were identified by COSEWIC 2008 and evaluated through the RPA (DFO 2011): impacts to habitat, direct mortality, water quantity and water quality. The watershed supports forestry, agriculture, a pulp mill, aquaculture, residential and recreational use, nearby roads and power transmission lines, and water storage for hydroelectric power generation. Threats to LURS resulting from human activities, and the degree of their impacts on each population are further

described, updated as necessary and re-assessed in the Lake Utopia Rainbow Smelt Small-bodied Population (LURS-SbP) Recovery Strategy (DFO 2016b).

IMPACTS TO HABITAT

The Large-bodied Population is particularly vulnerable to changes in water flow in Mill Lake Stream, the only stream with evidence of regular spawning since 2012. The culvert at the entrance to the stream was identified in the Recovery Strategy as a high-level concern because of its susceptibility to blockages. Beaver dams were observed and removed as a result of monitoring for spawning activity in March 2010, 2012 and 2017. Boulders lying below the main culvert were removed by New Brunswick Department of Transport in 2015.

Barriers also develop annually in Small-bodied Population spawning streams. Some barriers were observed and removed prior to the spawning season on both Smelt and Second brooks in 2015 and 2016 (MacDonald 2017; DFO unpubl. data). In 2016, stream flow across the beach delta at the mouth of all three spawning streams was considered inadequate to allow fish passage on several days, due to a weak spring freshet and low rainfall (MacDonald 2017). Partial barriers consisting of branches and organic debris were observed in Second and Smelt brooks in 2017 (DFO unpubl. data).

Impacts from foot traffic and the use of All Terrain Vehicles have been re-evaluated in the LURS recovery strategy (DFO 2016b) as a medium level threat to habitat for the Small-bodied population and low level threat to habitat for the Large-bodied Population. Streams used by the Small-bodied population are more likely to be crossed by ATV traffic, disturbing the substrate and directly impacting smelt staging before spawning in the spring.

DIRECT MORTALITY

The LURS-SbP Recovery Strategy identified the recreational dip net fishery as a low level of concern overall, given it is closed since the spring 2011, but a threat of an unknown level if unmitigated for the Large-bodied Population (DFO 2016b). An annual Aboriginal Food, Social and Ceremonial (FSC) smelt fishery is described as a potentially high-level threat for the Large-bodied Population because there is no population abundance estimate and, therefore, it is unknown how many can be removed without jeopardizing its survival (DFO 2016b). The FSC fishery operates under a single communal license and is managed cooperatively with the New Brunswick Aboriginal Peoples Council. The fishing season runs from April 15th to May 31st, and license conditions include a spawning season dip-netting closure within Smelt, Unnamed and Second brooks. The LURS Recovery Strategy exempts the FSC fishery for Small-bodied Population from the prohibitions under SARA because this population is considered large enough to sustain some directed fishing without jeopardizing its survival or recovery (DFO 2016b).

Two invasive species are present in the lake and a third is suspected. Smallmouth Bass has been established since 1942 without any apparent risk to LURS (DFO 2011). Anecdotal reports of Chain Pickerel in online fishing chat sites indicate that it is becoming established in Lake Utopia. It has been identified as a high level of concern for the Large-bodied Population, which is less abundant than the Small-bodied Population, and may compete with Chain Pickerel for resources or become a preferred food source (DFO 2016b). Eastern Charlotte Waterways (ECW) is conducting a project investigating the food preferences and size frequencies of Chain Pickerel in Lake Utopia through electrofishing and a recreational derby (Donald Killorn, ECW, pers. comm). Largemouth Bass may occur in the lake. One was reported from the St. George fishway in 2006 (Bradford et al. 2013) and there are unconfirmed reports of an additional three

individuals captured by recreational anglers in the past two years (Chris Burbidge, DFO, pers. comm.). Impacts of Largemouth Bass on LURS are unknown.

Other threats to LURS related to direct mortality are considered in the LURS-SbP Recovery Strategy to be of low concern (DFO 2016b). These include sampling for scientific research, entrainment at intakes for the paper mill, and bycatch in recreational fisheries. Predation by land-locked salmon, a species that is stocked every second year to support a recreational fishery, is considered a low level threat. A separate hatchery on the shore of Lake Utopia raising salmon for aquaculture has been closed for three years.

WATER QUANTITY

Changes in water quantity in both the Small-bodied and Large-bodied population spawning streams were identified as a high-level concern by the LURS-SbP Recovery Strategy (DFO 2016b) due to the potential to eliminate or reduce the productivity of one or more spawning streams. When water levels are too low, access to or exit from spawning sites can be impeded, while high water levels may result in backwatering, reducing the availability of oxygen to developing eggs in the head ponds of spawning streams. If fluctuations in Lake Utopia water levels are too severe, eggs may become vulnerable to excessive submergence or to desiccation as water levels change.

Water flows in tributaries are naturally variable; for example, water flow through the Mill Lake Stream culvert in April 2015 was so high as to exceed the swimming speed expected for smelt sized fish (MacDonald 2017). In contrast, water flow in 2016 in Scout Brook was so low in 2016 that smelt trying to access to the stream were impeded by a sand bar at the mouth of the stream (DFO unpubl. data).

Water quantity in Lake Utopia itself is conversely described as of low level of concern under existing mitigation. Lake water levels are monitored by the St. George Power Limited Partnership (SGPLP) hydroelectric facility. Since the dam was rebuilt in 2004, target minimum water level after the spring freshet was 57 feet until August 15th. Negotiations between DFO and SGPLP reduced this level to 54 feet in 2016.

WATER QUALITY

The LURS-SbP Recovery Strategy identified residential and recreational inputs and pesticide contamination as potential threats to LURS but with a low or medium level of concern. Stream monitoring by ECW in 2012 and 2013 indicated dissolved oxygen levels above minimum guidelines, low conductivity and dissolved metals. Cadmium levels in Mill Lake Stream were above minimum guidelines (DFO, unpubl. data).

New residential development has occurred recently along the edge of the lake, particularly around Second Brook and approaching Unnamed Brook. As per the *Clean Water Act*, temporary or permanent changes made at, near or to a watercourse or wetland or to the water flow in a watercourse or wetland requires a Wetland and Watercourse Alteration Permit (WAWA). This includes, but is not limited to, any disturbance of the ground or removal of trees within 30 metres of the lake. Proposals for land development have been reviewed by DFO Fisheries Protection Program to reduce risk to smelts. Also, the New Brunswick Species at Risk Section has recently developed a species at risk flagging tool, with the Department of Environment and Local Government, to identify any WAWA proposals that could affect Species at Risk, in order to provide comments or concerns.

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TABLES

*Table 1. Daily estimates of smelt reported in Mill Lake Stream in years in which night-time monitoring was undertaken (0: no smelt observed; MR: estimate generated by conducting a mark recapture experiment; dash-no observation; grey shading indicates daytime observations; *-dead smelt; Agent – MAPC - Maritime Aboriginal Peoples Council; ECW – Eastern Charlotte Waterways).*

Day	2009MR	2013	2014	2014MR	2017	2017MR
Agent	DFO	MAPC	MAPC	DFO	ECW	DFO
01-Apr	0	-	3,000	-	0	-
02-Apr	-	0	3,000	-	0	-
03-Apr	-	1*	270	1,724	0	-
04-Apr	-	5,500	8	3,082	25	-
05-Apr	-	3,500	2,750	14,542	0	-
06-Apr	-	2,000	4,000	12,058	0	-
07-Apr	-	2,000	3,000	-	120	-
08-Apr	-	0	8	-	165	-
09-Apr	-	-	-	-	0	-
10-Apr	-	-	-	23,658	200	-
11-Apr	-	-	-	-	2,000	-
12-Apr	-	-	-	-	3,000	-
13-Apr	-	-	7,000[1]	-	3,500	6,652
14-Apr	-	-	-	-	-	12,843
15-Apr	-	-	-	-	-	-
16-Apr	-	150	-	-	-	-
17-Apr	5,000	550	-	-	-	-
18-Apr	-	500	-	-	-	-
19-Apr	-	125	-	-	-	-
20-Apr	-	-	-	-	-	-
21-Apr	-	-	-	-	-	-
22-Apr	-	-	70[2]	-	-	-

[1] Smaller sized smelt than those observed April 1st to April 8th.
[2] Genotyping indicates that most of these were Small-bodied Population.

Table 2. Proportion of males and females observed during smelt spawning runs in Mill Lake Stream.

Year	Date	Number Males	Number Females	Proportion Female
2002	12-Apr	95	28	0.23
	13-Apr	45	18	0.29
2003	14-Apr	117	65	0.36
2009	16-Apr	50	11	0.18
	03-Apr	4	0	0
	05-Apr	174	48	0.22
2014	10-Apr	3	2	0.40
	14-Apr	94	34	0.27
2017	15-Apr	184	54	0.23

Table 3. Summary of genetic morph assignments for Lake Utopia smelt sampled in 2014 and 2015.Large: Large-bodied Population; Small – Small-bodied Population; Admix – hybridization exceeding criteria for Large or Small.

	GENETIC ASSIGNMENT*			
SAMPLE GROUP	**Large**	**Admix**	**Small**	**Total**
Mill Lake Stream 2014 'early large'	19	5	1	25
Mill Lake Stream 2014 April 22nd	1	2	12	15
Second, Smelt, Unnamed Brooks 2015	2	2	82	86

Table 4. Daily estimates of smelt reported in Unnamed Brook (UNB), Smelt Brook (SMB) and Second Brook (SCB) in years in which night-time monitoring was undertaken (0: no smelt observed; dash - no observation).

	UNB		SMB	SCB
Date	2013	2014	2014	2014
12-Apr	-	0	0	0
13-Apr	-	-	-	-
14-Apr	-	-	-	-
15-Apr	-	-	-	-
16-Apr	-	-	-	-
17-Apr	-	-	-	-
18-Apr	-	-	-	-
19-Apr	-	-	-	-
20-Apr	-	-	-	-
21-Apr	-	-	-	-
22-Apr	-	-	-	-
28-Apr	-	-	-	-
29-Apr	1,200		-	-
30-Apr	10,000	-	-	-
01-May	12,000	-	-	-
02-May	2,000	100	300	0
04-May	-	-	-	-
05-May	-	-	-	-
06-May	-	-	-	-
07-May	-	-	-	-
08-May	-	-	-	-
09-May	-	30	-	-

FIGURES

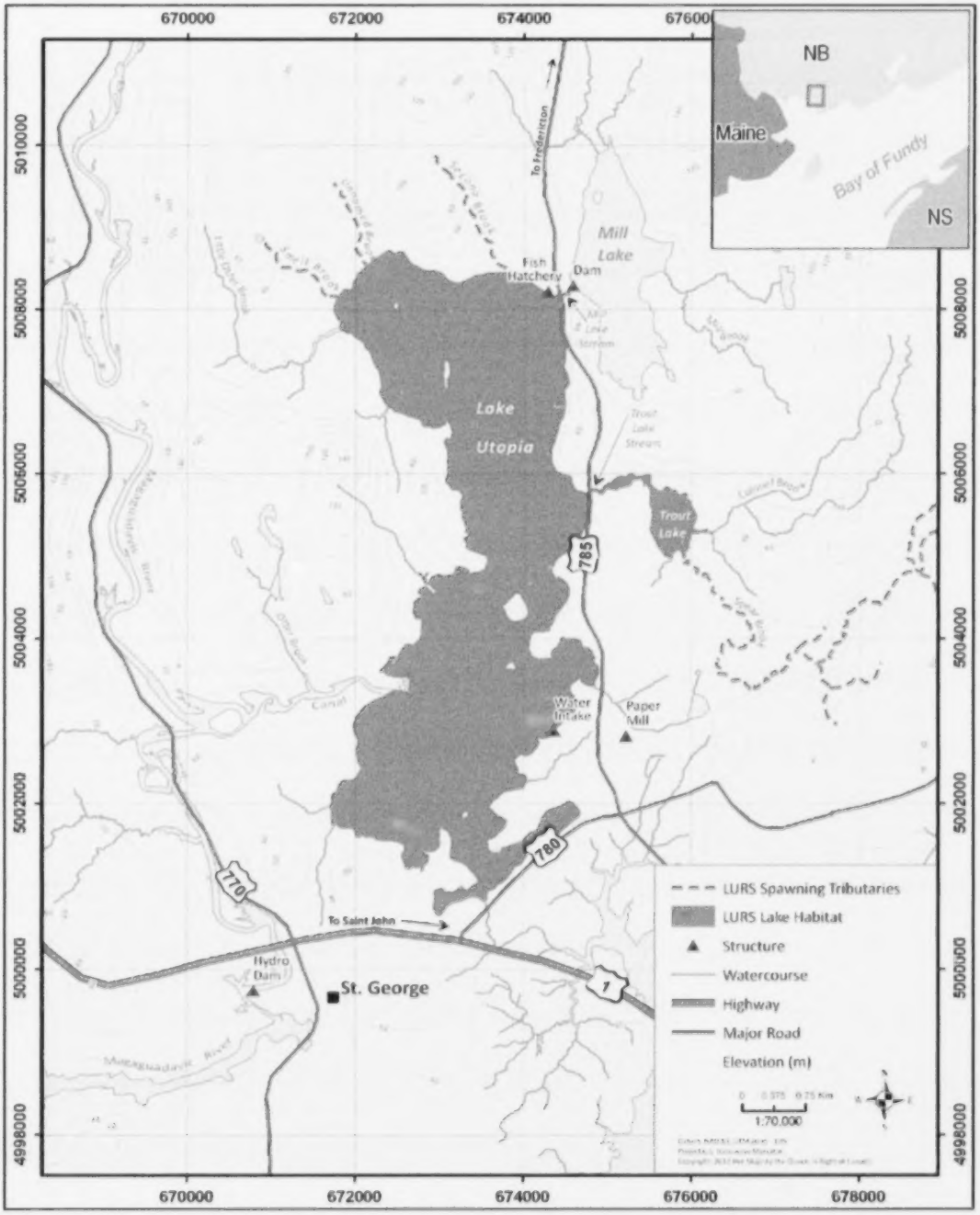

Figure 1. Lake Utopia, New Brunswick. Spawning tributaries for Lake Utopia Rainbow Smelt are highlighted.

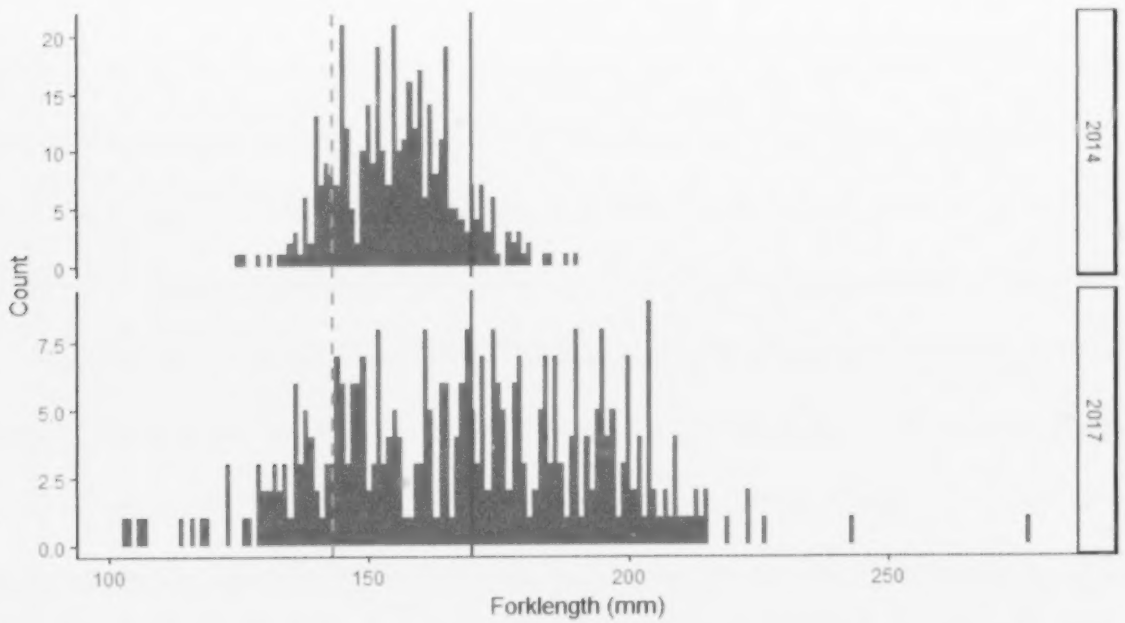

Figure 2. Length frequency of Mill Lake Stream smelt run. Upper panel: 2014 (n= 348); lower panel: 2017 (n=378). Blue vertical line indicates minimum fork length (mm) determining Large-bodied Population according to DFO (2011); red dashed line indicates minimum fork length based on genetic analyses of 2014-15 samples (DFO 2018).

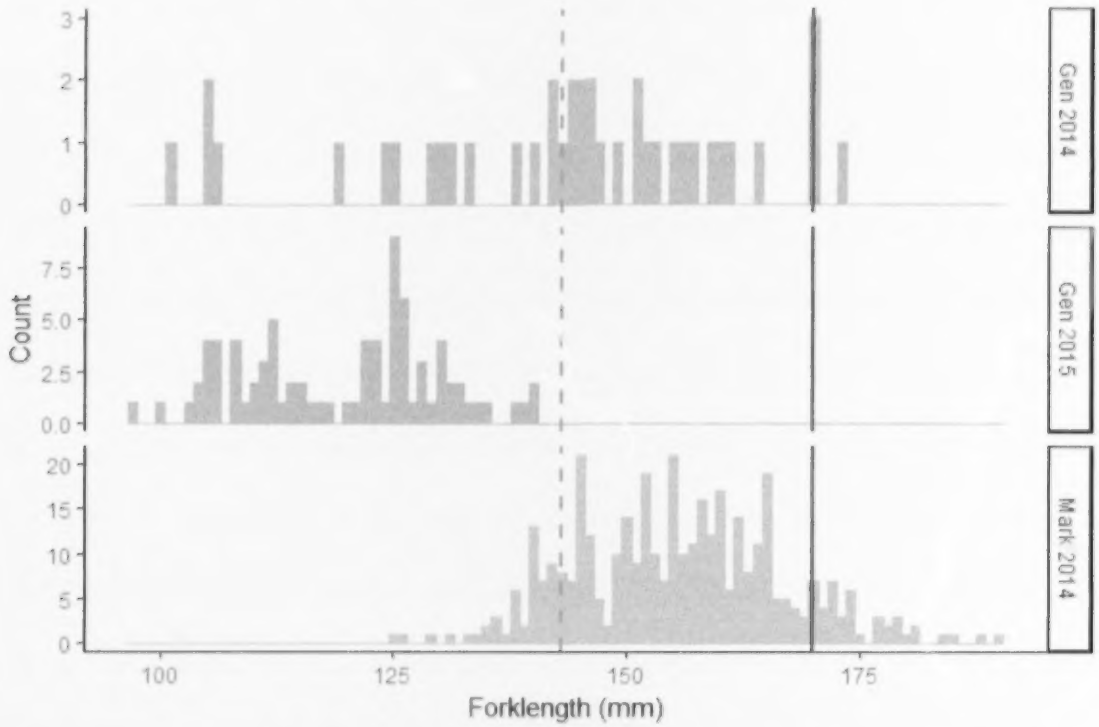

Figure 3. Length frequency distributions of Lake Utopia Rainbow Smelt sampled in 2014 (Gen 2014) and 2015 (Gen 2015) for genetic analyses and for an abundance study in 2014 (Mark 2014). Purple – Small-bodied Population; orange – hybridized genotype; green – Large-bodied Population; blue – no genotype analysis. Blue vertical line indicates minimum fork length (mm) determining Large-bodied Population according to DFO (2011); red dashed line indicates minimum fork length based on genetic analyses of 2014-15 samples.

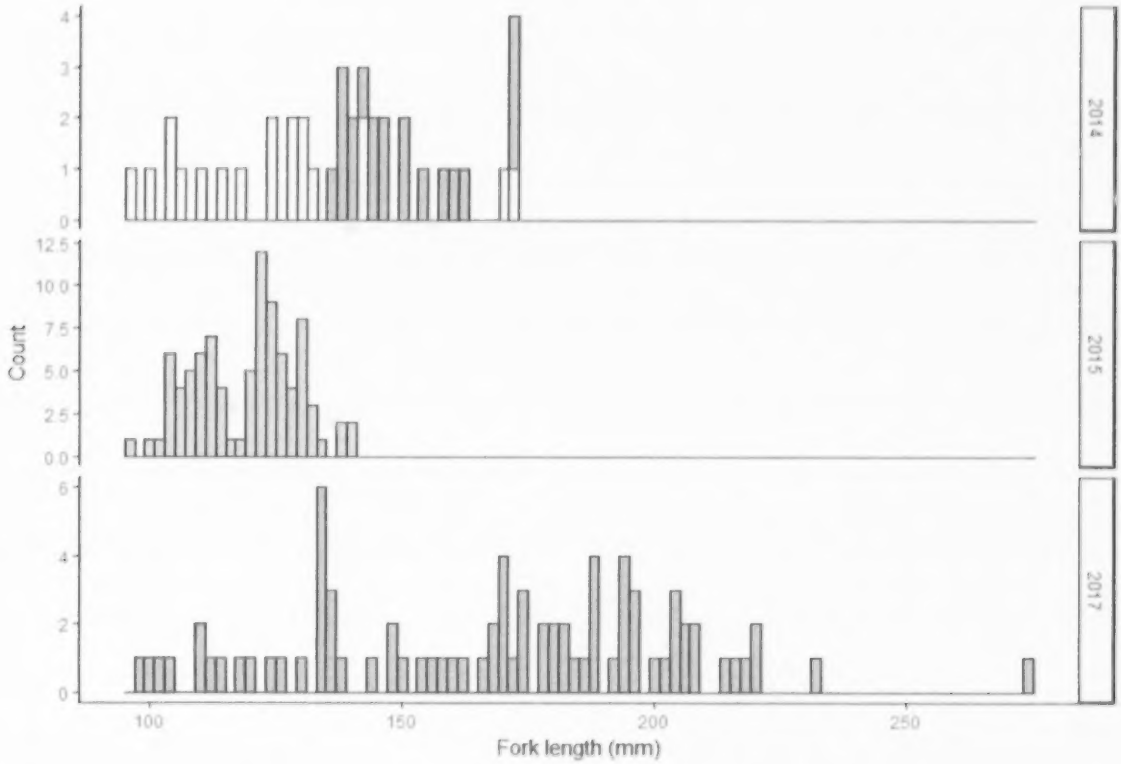

Figure 4. Fork length (mm) distribution of smelt sampled for gill raker counts from 2014, 2015 and 2017. Orange: smelt sampled during Mill Lake Stream run in 2014, 2017; yellow – smelt sampled from second Mill Lake Stream run (April 22, 2014); green – smelt sampled in Unnamed, Second and Smelt brooks.

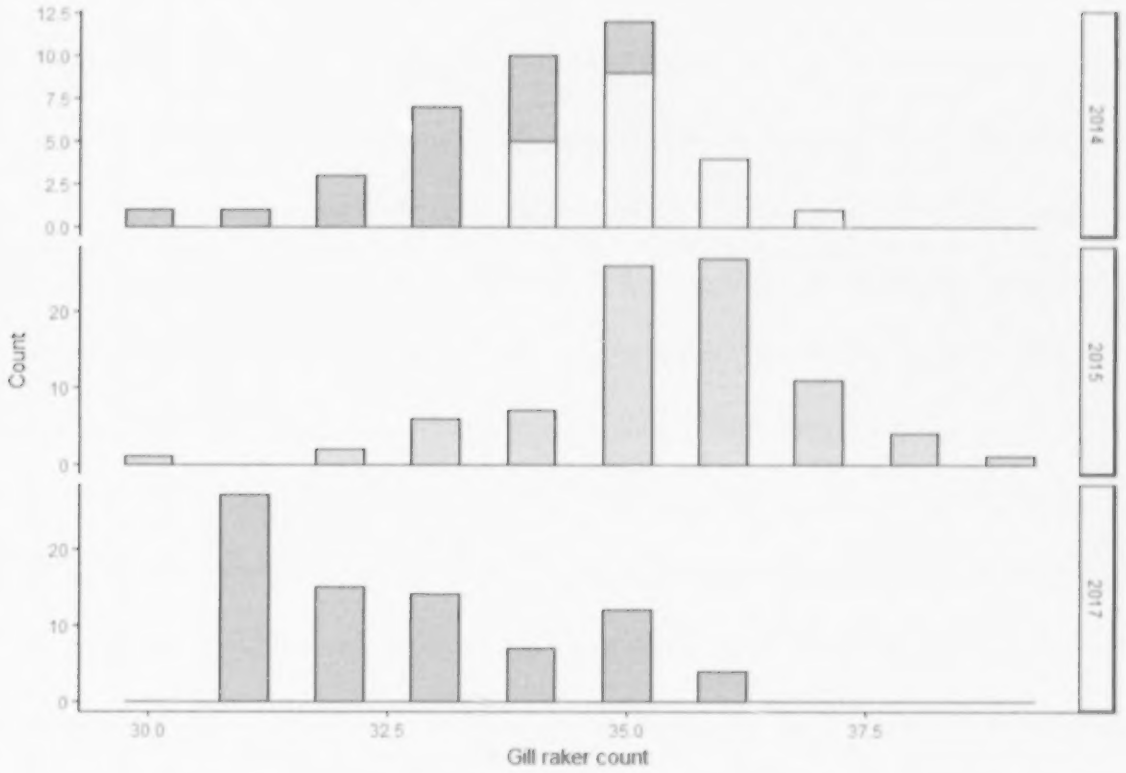

Figure 5. Gill raker counts of smelt sampled from 2014, 2015 and 2017.Orange: smelt sampled during Mill Lake Stream run in 2014, 2017; yellow – smelt sampled from second Mill Lake Stream run observed on April 22, 2014; green – smelt sampled in Unnamed, Second and Smelt brooks.

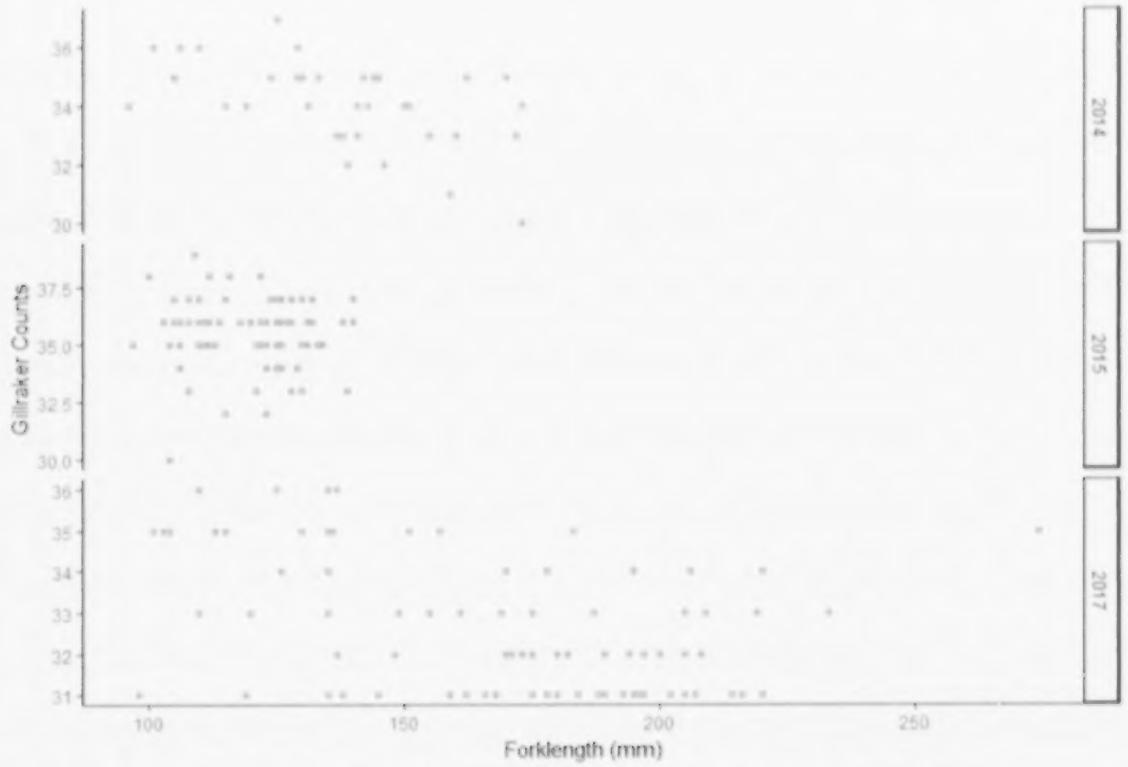

Figure 6. Gill raker counts and fork length (mm) for samples of Lake Utopia Rainbow Smelt from 2014, 2015 and 2017. Orange: smelt sampled during Mill Lake Stream smelt run in 2014, 2017; green – smelt sampled from second Mill Lake Stream smelt run observed on April 22, 2014; blue – smelt sampled in Unnamed, Second and Smelt brooks.

APPENDICES

APPENDIX 1. MONITORING AND OTHER STUDIES CONDUCTED ON LAKE UTOPIA TRIBUTARY STREAMS FROM 2012-2017.

(MLS: Mill Lake Stream; TLS: Trout Lake Stream; SPB: Spears Brook; SCB: Second Brook; UNB: Unnamed Brook; SMB: Smelt Brook; ECW - Eastern Charlotte Waterways; MAPC -Maritime Aboriginal Peoples Council; MPGL: Marine Probe Gene Laboratory).

Year	Dates	Objectives	Protocols	Agent
2012	March 12th - late June	Presence-absence surveys of smelt in MLS, TLS, SCB, UNB, SMB, identify potential barriers, water chemistry	Daytime checks once per week Dissolved oxygen, conductivity, passive monitor depth and temperature	ECW
	March 22nd - March 27th	Checking water levels and potential barriers in MLS	Daytime checks daily	DFO
2013	March 21st - May 6th	Presence-absence surveys of smelt in MLS, SCB, UNB, SMB, spawner counts	3-4 checks per weekduring nighttime after April 4.	MAPC
	April 30th – May 1st	Install temperature recorders, identify potential spawning habitat in tributaries	Visits to 16 brooks, checks for presence/absence of smelt, eggs	DFO
	April 10th – May 30th	Presence-absence surveys of smelt in MLS, TLS, SCB, UNB, SMB, identify potential barriers, water chemistry	Weekly checks (daytime), Dissolved oxygen, conductivity, passive monitor depth and temperature	ECW
2014	April 1st – May 6th	Presence absence surveys and counts of smelt in MLS,TLS, SCB,SMB, UNB	MLS - Nightly checks and counts at 0.5-1 hour intervals; weekly day or night checks of other streams (no observations April 14-May 2)	MAPC
	April 3rd - 10th	Mark-recapture study to estimate abundance in MLS; collection of biological data	Two capture events each night, biological data	DFO
2015	April 1st – May 14th	Presence absence surveys of smelt in MLS, TLS, SPB, SCB, UNB, SMB; mapping habitat in MLS, water flows	Daytime checks one-three times per week of MLS; two checks of other streams	DFO
2016	March 10th – May 26th	Presence absence surveys of smelt in MLS, TLS, SCB, UNB, SMB	Daytime checks once per week of MLS; three visits to other streams	DFO
	Spring 2016	Genetics of smelt collected from MLS and SCB and Harvey Lake	Genetic analyses of tissue samples collected in 2014-15	MPGL Dalhousie University
2017	March 20th – May 22nd	Presence absence surveys of smelt in MLS, SCB, UNB, SMB,	Nighttime checks of MLS March – April 12; weekly daytime checks of other streams	ECW, MAPC
	April 13th – 14th	Mark-recapture study to estimate abundance in MLS	Two capture events each night, biological data	DFO

APPENDIX 2. OBSERVED OCCURRENCES OF LAKE UTOPIA RAINBOW SMELT IN MILL LAKE STREAM AND TROUT LAKE STREAM FROM 2012-2017.

(0-no smelt observed (grey cell), 1 – smelt present. Amounts: light blue cell – few smelt; medium blue cell – small schools of smelt; dark blue cell– lots of smelt; asterisk – single, dead animal; E- eggs only observed (yellow cell); dash-no observation;). Night Sampling: range of days when observations occurred between 23:00-04:00 hours.

	Mill Lake Stream						Trout Lake Stream					
Year	2012	2013	2014	2015	2016	2017	2012	2013	2014	2015	2016	2017
Night Sampling	Apr 6 only	Apr 4-May 15	Apr 1-9	Only April30	None	Mar 30-Apr 15	None	None	Apr 1-9	None	None	Mar 20-Apr 15
20-Mar	-	-	-	-	-	0	-	-	-	-	-	0
21-Mar	-	0	-	-	-	-	-	-	-	-	-	-
22-Mar	0	-	-	-	-	0	-	-	-	-	-	0
23-Mar	0	-	-	-	-	-	-	-	-	-	-	-
24-Mar	0	-	-	-	-	0	-	-	-	-	-	0
25-Mar	-	0	-	-	-	-	-	-	-	-	-	-
26-Mar	0	0	-	-	-	0	-	-	-	-	-	0
27-Mar	0	0	-	-	-	-	-	-	-	-	-	-
28-Mar	-	0	-	-	-	0	-	-	-	-	-	0
29-Mar	-	-	-	-	-	-	-	-	-	-	-	-
30-Mar	-	-	-	-	-	0	-	-	-	-	-	0
31-Mar	-	-	-	-	-	-	-	-	-	-	-	-
01-Apr	-	-	1	0	0	-	-	-	0	0	0	-
02-Apr	-	0	1	-	-	-	-	-	0	-	-	-
03-Apr	-	1*	1	-	-	-	-	-		-	-	-
04-Apr	-	1	1	-	-	1	-	-		-	-	0
05-Apr	-	1	1	-	-	-	-	-	0	-	-	-
06-Apr	1*	1	1	-	0	-	0	-		-	0	-
07-Apr	-	1	1	-	-	1	-	-	0	-	-	0
08-Apr	-	-	1	0	-	1	-	-	0	0	-	0
09-Apr	-	-	0	-	-	0	-	-	0	-	-	0
10-Apr	-		-	-	-	1	-	0	-	-	-	0
11-Apr	-	-	-	-	-	1	-	-	-	-	-	0
12-Apr	-	-	0	-	-	1	-	-	0	0	-	0
13-Apr		-	1	0	1*	1	1	-	-	0	0	0
14-Apr	-	-	-	-	-	1	-	-	-	-	-	0
15-Apr	-	-	-	0	-	-	-	-	-	-	-	0
16-Apr	0	1	-	-	-	-	0	-	-	-	-	-
17-Apr	-	1	-	0	-	-	-	E	-	-	-	-
18-Apr	-	1	-	-	-	-	-	-	-	-	-	-
19-Apr	-	1	-	-	-	-	-	-	-	-	-	-
20-Apr	0	-	-	0	-	-	0	-	-	-	-	-
21-Apr	-	-	-	-	E	-	-	-	-	-	0	-
22-Apr	-	-	1	0	-	-	-	-	-	0	-	-

	Mill Lake Stream						Trout Lake Stream					
Year	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Night Sampling	Apr 6 only	Apr 4-May 15	Apr 1-9	Only April30	None	Mar 30-Apr 15	None	None	Apr 1-9	None	None	Mar 20-Apr 15
23-Apr	-	0	-	-	-	-	-	0	-	-	-	-
24-Apr	-	-	-	0	-	-	-		-	-	-	-
25-Apr	-	-	E	-	-	-	-		-	-	-	-
26-Apr	-	-	-	-	-	-	-		-	-	-	-
27-Apr	-	-	-	0	E	-	-	-	-	-	0	-
28-Apr	-	-	-	-	-	E	-	-	-	-	-	0
29-Apr	-	0	-	E	-	-	-	-	-	0	-	-
30-Apr	0	0	-	E	-	-	0	-	-	0	-	-
01-May	-	0	-	E	-	-	-	0	-	0	-	-
02-May	-	0	-	-	-	E	-	-	-	-	-	-
03-May	-	-	-	-	-	-	-	-	-	-	-	-
04-May	0	-	-	E	0	-	0	-	-	0	0	-
05-May	-	-	-	-	-	E	-	-	-	-	-	-
06-May	-	0	-	E	-	-	-	0	-	-	-	-
07-May	-	-	-	-	-	-	-	-	-	0	-	-
08-May	-	-	-	-	-	-	-	-	-	-	-	-
09-May	-	-	0	-	-	E	-	-	0	-	-	-
10-May	-	-	-	-	-	-	-	-	-	-	-	-
11-May	0	-	-	-	-	-	0	-	-	-	-	-
12-May	-	-	-	-	0	0	-	-	-	-	0	-
13-May	-	-	-	-	-	-	-	-	-	-	-	-
14-May	-	-	-	E	-	-	-	-	-	-	-	-
15-May	-	0	-	-	-	0	-	0	-	-	-	-
Number of visits	10	16	13	15	5	21	7	6	8	10	7	17

APPENDIX 3. OBSERVED OCCURRENCES OF LAKE UTOPIA RAINBOW SMELT IN SMELT BROOK, UNNAMED BROOK AND SECOND BROOK FROM 2012-2017 DURING DAYTIME MONITORING.

(0-no smelt observed (grey cell), 1 – smelt present; E- eggs only observed (yellow cell); dash-no observation; light blue cell – few smelt; medium blue cell – small schools of smelt; dark blue cell– lots of smelt).

	Smelt Brook						Unnamed Brook						Second Brook					
Day Year	12	13	14	15	16	17	12	13	14	15	16	17	12	13	14	15	16	17
01-Apr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-
02-Apr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
03-Apr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
04-Apr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
05-Apr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
06-Apr	0	-	-	-	-	-	0	-	-	-	-	-	0	-	-	-	1	-
07-Apr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
08-Apr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
09-Apr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10-Apr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11-Apr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12-Apr	-	-	0	-	-	-	-	-	0	-	-	-	-	-	0	-	-	-
13-Apr	1	-	-	-	-	-	1	-	-	-	-	-	0	1	-	-	1	-
14-Apr	-	-	-	-	0	-	-	-	-	-	1	-	-	-	-	-	1	-
15-Apr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16-Apr	0	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-
17-Apr	-	E	-	–	-	-	-	0	-	-	-	-	-	-		-	-	-
18-Apr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19-Apr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20-Apr	1	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-
21-Apr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	E	-
22-Apr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23-Apr	-	1	-	-	-	-	-	-0-	-	-	-	-	-	1	-	-	-	-
24-Apr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25-Apr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26-Apr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27-Apr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
28-Apr	-	-	-	-	-	E	-	-	-	-	-	E	-	-	-	-	-	1
29-Apr	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
30-Apr	0	1	-	-	-	-	E	1	-	-	-	-	0	1	-	-	-	-
01-May	-	1-	-	-	-	-	-	1	-	-	-	-	-	0	-	-	-	-
02-May	-	-	1	-	-	E	-	1	1	-	-	E	-	-	0	-	-	E
03-May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

	Smelt Brook						Unnamed Brook						Second Brook					
Day Year	12	13	14	15	16	17	12	13	14	15	16	17	12	13	14	15	16	17
04-May	1	-	-	-	-	-	0	-	-	-	-	-	0	-	-	1	1	-
05-May	-	-	-	1	-	E	-	-	-	1	-	E	-	-	-	-	-	-
06-May	-	1	-	-	-	-	-	E	-		-	-	-	-E	-	1	-	-
07-May	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	1	-	-
08-May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
09-May	-	-	-	-	-	E	-	-	1	-	-	E	-	-	-	-	-	E
10-May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11-May	-	-	-	-	-	-	0	-	-	-	-	-	0	-	-	-	-	-
12-May	-	-	-	-	0	E	-	-	-	-	1	E	-	-	-	-	E	E
13-May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14-May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
15-May	-	0	-	-	-	0	-	E	-	-	-	0	-	0	-	-	-	0
16-May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17-May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18-May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
19-May	-	-	-	-	-	0	-	-	-	-	-	0	-	-	-	-	-	-
20-May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21-May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22-May	-	E	-	-	-	0	-	E	-	-	-	0	-	-	-	-	-	0
23-May	-	0	-	-	-	-	-	E	-	-	-	-	-	0	-	-	-	-
24-May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25-May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26-May	-	-	-	-	0	-	-	-	-	-	0	-	-	-	-	-	0	-
Number of visits	6	7	2	2	3	8	7	9	3	2	3	8	7	5	2	4	9	7